Beam size measurement via vertical polarization component of SR at KEKB?

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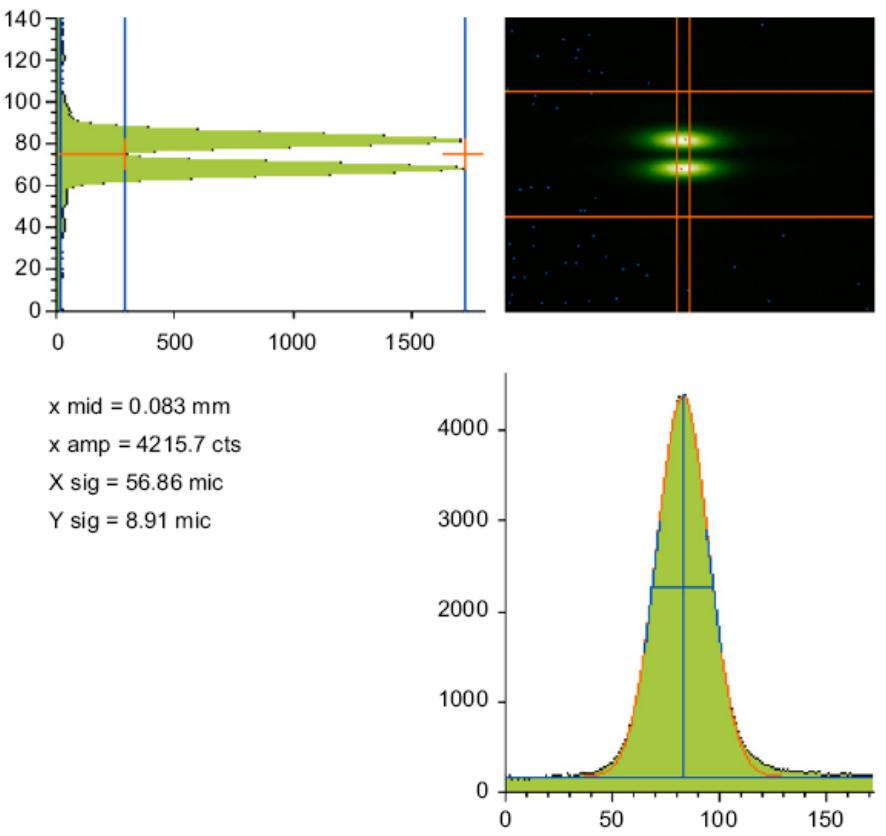
Background

- Swiss Light Source measured beam sizes <10 um using vertical polarization component of SR
  - A. Andersson et al., NIMPR A 591 (2008) 437-446
- Question was asked: can this technique be used at KEKB?

Å. Andersson et al. / Nuclear Instruments and Methods in Physics Research A 591 (2008) 437–446



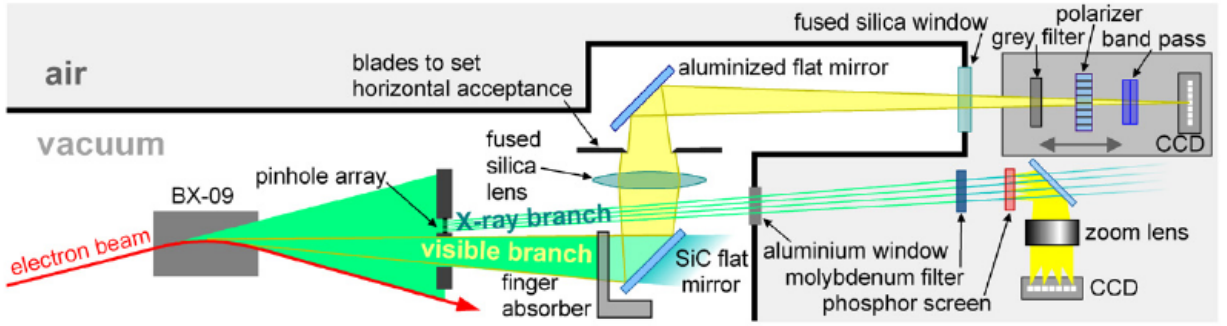
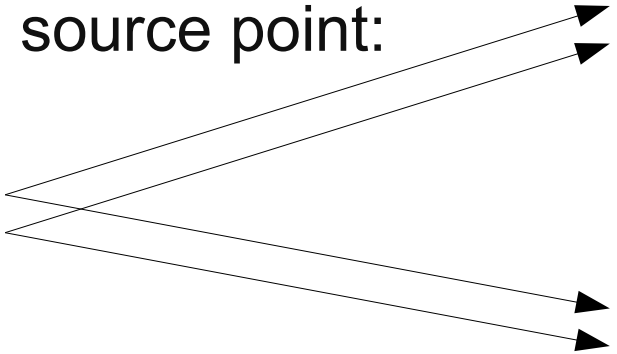


Fig. 1. Top view of the diagnostic beamline, showing the X-ray branch with pinhole array and the vis–UV branch.

Principle

- Vertical polarization component of SR has two peaks in vertical angular axis, goes to zero in middle for point source.
- Finite-sized source produces smeared distribution, so can measure beam size from peak-valley ratio, similar to interferometer.
- Note: Smearing is greater the closer one gets to the source point:



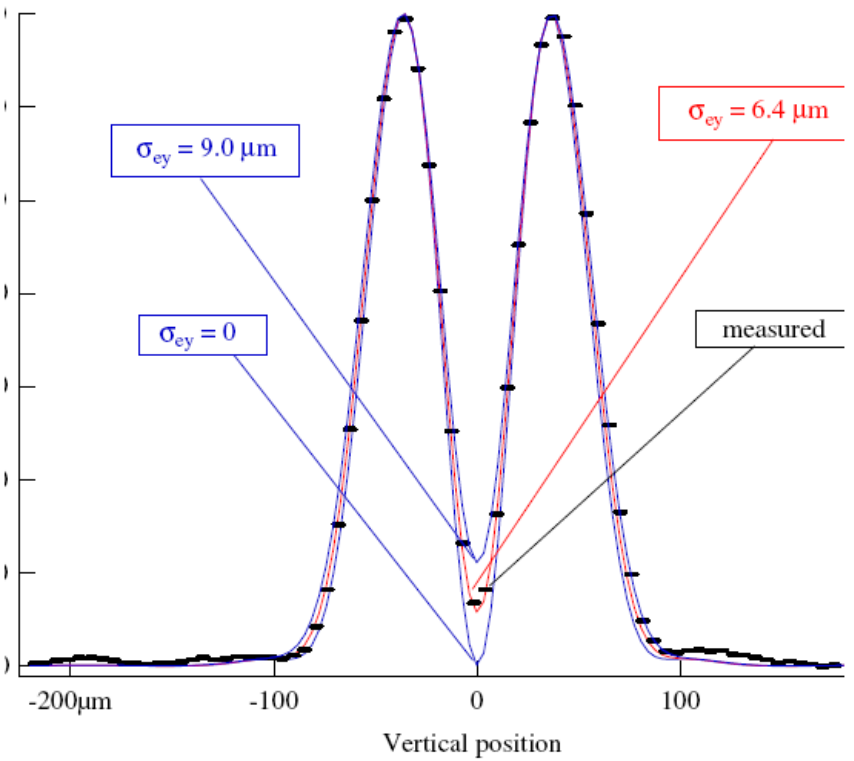
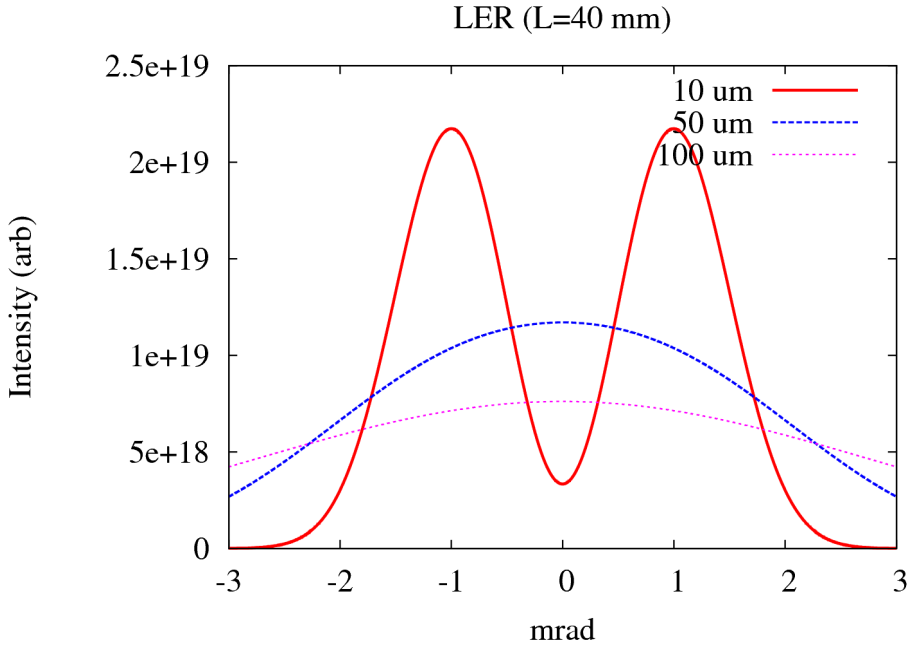


Fig. 8. Measured (marks) and predicted (three solid lines) vertical image profiles. $\lambda = 364\,\mathrm{nm}$; acceptance angles $3.9\,\mathrm{mrad_H}/9.0\,\mathrm{mrad_V}$. Machine conditions: 400 mA in top-up operation; tuned skew quads.

$$E_\pi(x,y) = E_{\pi 0}\,\mathrm{sinc}\left(\frac{2\pi x_c}{\lambda p'}x\right) \times \int_0^{+\infty}(1+\xi^2)^{1/2}\xi K_{1/3}\left(\frac{1}{2}\frac{\lambda_c}{\lambda}(1+\xi^2)^{3/2}\right)\sin\left(\frac{2\pi p}{\lambda\gamma p'}y\xi\right)\mathrm{d}\xi \quad (1)$$

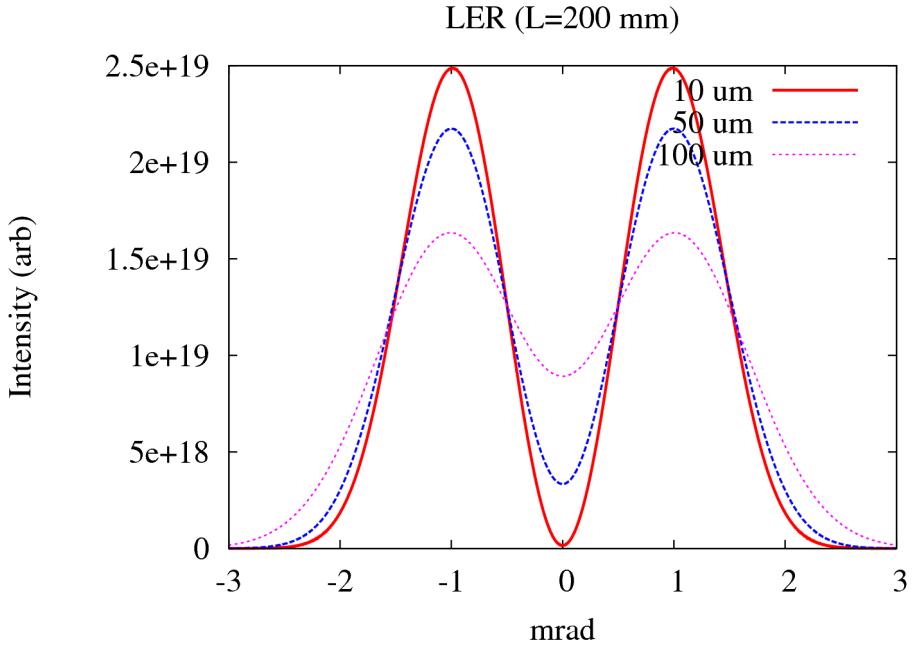
KEKB LER

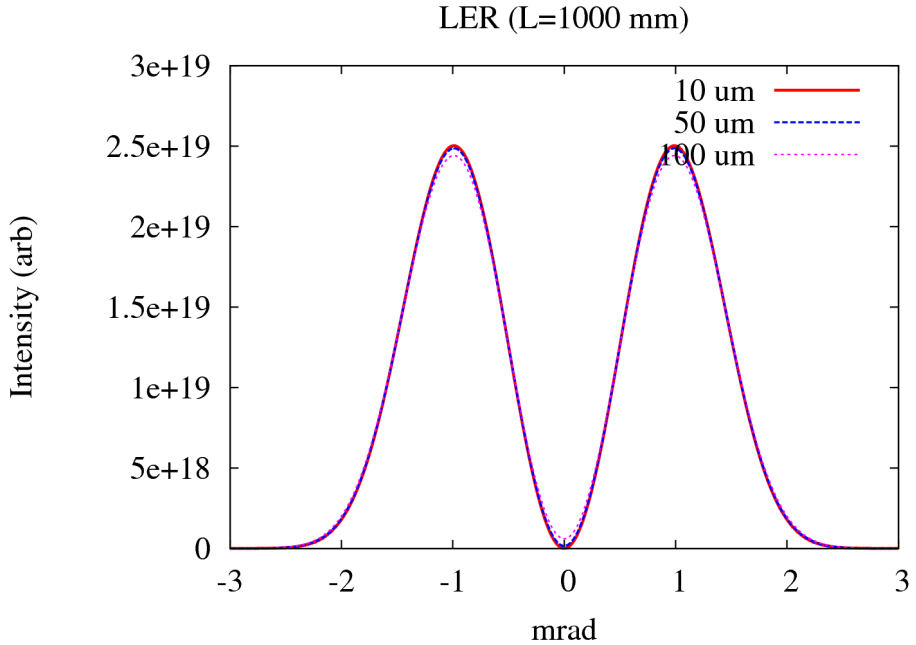


- Using Kim (AIP 184 (1989)), Eq. 3.12:

$$\frac{dF}{d\Omega} = \frac{3\alpha}{4\pi^2}\gamma^2 \frac{\Delta\omega}{\omega}\frac{I}{e}\left(\frac{\omega}{\omega_c}\right)^2 (1+X^2)X^2 K_{1/3}^2(\eta)$$

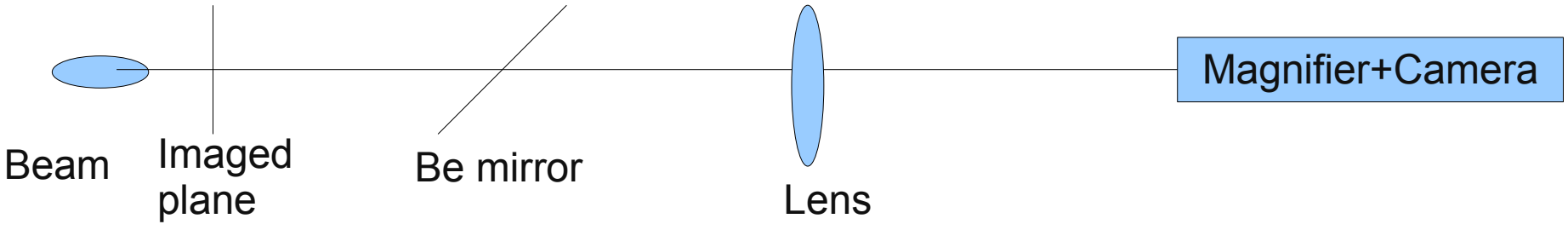
$$X = \gamma\psi\,;\,\eta = \frac{1}{2}\frac{\omega}{\omega_c}(1+X^2)^{3/2}$$





KEKB LER (cont).

- Measurement is in principle possible at current KEKB LER.
- Requires imaging point 200 mm downstream of source point.
- How to calibrate?
  - Beryllium mirror distortion will change focal length
  - One possibility: with camera (and magnifier) on movable stage, can find beam source position and Be mirror position. Then interpolate.



Error estimate

- 1/f = 1/p + 1/p'
  - f = focal length of lens
  - p' = lens-camera distance
  - p = imaged plane to lens distance
  - Note: beam to lens =~60 m (LER2)
- For f = 1 m:
  - Beam focuses at p' = 1.017 m
  - Be mirror focuses at p' = 1.026 m
  - If we have a stage which can cover 1 cm with 1 um accuracy, then a 1 um error in p' translates to a 3.5 mm error in p. This is 2% of the 20 cm distance from beam.
- Note: A 1 cm source depth (5% of beam-imaged plane distance, similar to Swiss Light Source), requires a 1 cm-wide aperture at 60 m. This is reasonable.

Summary

- The measurement is in principle doable at present KEKB.
- Mirror distortion will introduce a huge beam current dependence, so this would not be usable as a daily monitor without heat-distortion-free optics.
- It could potentially be useful as a cross-check.